ELECTRIC LIGHTING AND POWER RATES

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Electric lighting and power plants like other public utilities must furnish adequate service at reasonable rates without unjust discrimination. What constitutes adequate service and reasonable rates is largely a question of facts. Adequate service requires efficient and well-maintained equipment, uniform and well kept-up voltage, accurate meters and many other things that can only be had through close supervision. What are reasonable rates is a matter that depends very largely on the circumstances under which the service is furnished. Plants that are operating under abnormal conditions may have to accept business at rates that yield much less than what might otherwise be regarded as reasonable compensation. When conditions are normal, the plants are in law entitled to rates that will cover reasonable allowances for operating expenses, including depreciation, and interest and profits on a fair value of the plant and the business. Such allowances may be said to constitute the normal cost of the service. As normal costs are also the economic basis for normal prices, there appears to be a close relation between the legal and the economic bases for rates.

The work involved in the making of reasonable rates for electric and other utilities is thus largely made up of determining what is the fair total cost of the service and what proportion of this cost should be borne by each of the different branches of the service and by the different classes of customers or individual customers in each of these branches. In order to find these costs, it is necessary to determine the fair value of the property and business that is employed in serving the public, the rates that constitute reasonable allowances thereon for interest, profits and depreciation on this value, as well as what is a fair allowance for other operating expenses.

The fair value of the property and the business is largely determined from those facts which show their original cost and what it would cost to reproduce them, both new and in their existing con-

dition. The rate of returns for interest and profits is mostly found from facts which indicate the rate at which the capital and the business ability for the plant in question, and for other enterprises where conditions are similar, can be had, the condition of the investment market generally and from other facts of this nature. The amount to be allowed for depreciation is usually found from the cost of and the length of the useful life of the property actually involved, as well as from the total cost and composite life of the plant as a whole. The fair cost of operation is mostly determined from close studies of the management, its methods and practices, the condition of the equipment, and the circumstances under which the services are rendered. In all inquiries of this kind, comparisons as between different plants and other facts in point are of much importance.

It is hardly necessary to say that, since the cost of the service is the basis for the rates, it is very important that this cost so found, not only for the plant as a whole, but also for each branch and class of the service, should be the correct or fair cost. The rates charged for utility service may vitally affect not only the social income and its distribution, but the industrial and commercial development of entire communities, and the conditions under which individual enterprises are carried on. Unless such rates are fair and equitable, it is almost certain that some plants will earn more and others less than they should earn, and some customers will have to bear more than a fair share of the total cost, while others are charged less. Such inequalities frequently spell success for some customers at the expense and even ruin of others. Owing to the fact that the theories and facts involved in this are often conflicting and very complicated, it is usually rather difficult to determine, not only the fair cost of the service, but also what is an equitable rate for the same. These obstacles, however, are not so serious that they cannot be overcome. Through close studies of the facts and conditions in each case, and by the application of correct methods to the calculations and the apportionments that are required, it is usually both possible and practicable to arrive at a fair result.

Ordinarily the cost of utility service is divided into the operating expenses proper, and fixed charges. The former include the expenses of operating the plant, or those items which would stop if operation were discontinued. The fixed charges cover such outlays of taxes, the depreciation due to the time or the elements, and interest

and profits; that is, those costs which go on even if operations are stopped. Both of these classes of costs are actually as well as relatively higher for some branches and classes of the service than for others, depending upon whether the service is furnished closer to or farther away from the power plant, upon whether the service demanded is for a longer or shorter period daily, and upon other local conditions.

Under normal conditions each branch should bear its own operating expenses, together with its full share of the interest charges. When conditions are abnormal, it may be necessary to so shift the interest charges that some branches bear less and others more than their normal share of the same. Ordinarily no part of the service should be allowed rates that are so low as not to cover the operating expenses plus at least something for the interest on the investment. For business that cannot be had on better bases, the cost may have to be so construed as to mean only the additional costs that are incurred in taking such business on. Mere inequalities in rates are not regarded as unjust until the point is reached where they result in some injustice to some one else. What is thus true in these respects for the different branches of the service is also true for the various classes of customers in each branch.

In the public utility field, where monopoly conditions largely prevail, this cost is about the only available basis for a fair price. While this is generally admitted, there is some division of opinion as to whether the rate should be governed by the average cost per unit that is obtained when the total cost is divided by the total units sold, or by the amounts per unit that are obtained when, in computing them, the demand, the length of daily use of the installation, and other factors in point are also considered. That the latter method furnishes the most equitable units for rate-making purposes becomes quite apparent when the nature of the electric energy business and the conditions by which it is surrounded are taken into account.

The nature of the electric utility is such that its product is more of a service than a commodity. The service it renders must be used in connection with the plant because it cannot be stored except to a limited extent. As electricity is largely used for lighting, the greatest demand on the plant is in the evening. While this maximum demand may not last long, the plant must be large enough to meet it. The demand on the plant also varies with the seasons, being

much greater during the winter than during the summer months. The effect of such variation in the demand is that for the greater part of the time as much and more than 80 per cent of the capacity of most plants remains idle.

Public utility service is also decidedly a service of decreasing costs. As much as two-thirds or more of the total expense of the service, when fixed charges are included therein, are often independent of the amount of current or energy generated and are about as great when the output of current is smaller as when it is greater. Hence, the greater the amount of current that can be sold, up to the point where the full capacity of the plant is constantly utilized, the better is the load factor and the lower the cost per unit of current will be.

In order to illustrate this point let us assume a plant that has a capacity of 300 kilowatts; that has an average daily use of current of about four hours; that has an operating expense including taxes and interest on the investment of $18,000 per year, of which 60 per cent is covered by the fixed and 40 per cent by the variable expenses; and that has an instantaneous demand that about equals the capacity of the plant. The fixed expenses, on the basis stated, amount to a total of $10,800 for the year, or $36 per kilowatt of demand per year. This expense remains the same whether the plant is operated one, two or three hours daily or even if it is in operation all day. Such being the case it must follow that the fixed cost per kilowatt hour decreases with the increase in the output. If the plant were operated only one hour each day, it would be operated 365 days in a year and the fixed cost per kilowatt hour of output would be 9.86 cents. If the plant were operated two hours each day the output would just be doubled and the fixed charge per kilowatt hour would be halved. Thus the fixed cost per kilowatt hour for different hours daily operation of the plant is as follows:

When the plant is in operation 1 hour daily 9.86 cents.
When the plant is in operation 2 hours daily 4.93 cents.
When the plant is in operation 3 hours daily 3.29 cents.
When the plant is in operation 5 hours daily 1.97 cents.
When the plant is in operation 10 hours daily .99 cents.

The variable expenses, according to our assumption, amount to $7,200 a year when the plant is in full operation an average of

four hours a day. This means a variable cost of 1.65 cents per kilowatt hour, which increases or decreases in exact proportion to the increase or decrease in the number of kilowatt hours generated.

The total cost of current, as stated, is thus made up of a fixed and a variable expense. When these are reduced to a unit basis and added together, the results shown in the following table are obtained:

Number of hours plant is operated daily	Fixed	Variable	Total
			cents per k.w. hour
1	9.86	+ 1.65 =	11.51
2	4.93	+ 1.65 =	6.58
3	3.29	+ 1.65 =	4.94
5	1.97	+ 1.65 =	3.62
10	0.99	+ 1.65 =	2.64

These facts better than anything else show the fallacies of a uniform rate per kilowatt hour, and indicate that the consumer who uses his installation only a short time each day should not be given the same rate as the one who uses his installation a comparatively longer time.

In view of these and other facts, in order that they may become proper bases for rates, it is necessary to analyze closely the expenses of a plant and to classify them in accordance with their nature, branches of the service and classes of customers. In thus studying their nature, it is found that some of the cost items depend directly on the capacity of the plant and vary with this capacity; that others depend directly on the customers of the plant, and vary with the number of customers; and that there are still other items which depend directly on the output of energy and vary with variations in the amount of this output. It is further found that there are also many items in the cost of the service which do not depend directly upon the demand, the customers, or the output, but which are indirectly dependent upon two or more of them. They are in the nature of overhead charges. In addition to this, it is also found that some of these expense items are relatively higher for some branches or parts of the service than for others.

In order to establish rates that are equitable to all it is necessary to separate those expenses which depend directly on the demand, the customers, and the output into their respective classes. It is

further necessary to apportion properly the indirect or overhead expenses between these classes in such a way that each class is made to bear its proper share thereof. In addition to this it is also necessary to apportion properly these classes of expenses between the different branches of the service. Likewise the customers must also be classified by branches of the service, while those in each branch may have to be grouped in accordance with their demand on the plant and other characteristics of the service they obtain.

Now, these conditions and apportionments are logical and well within reason. If this is the case then it would also seem equally logical and reasonable that each customer or class of customers should bear his or their just proportion of such of the three classes of expenses that were named. That is, they should bear demand costs in proportion to their respective demand in kilowatt on the plant; they should bear customers' cost in proportion to the number of customers; they should bear output costs in proportion to the respective amounts of current or energy used.

When the demand costs are thus allotted to the customer on the basis of the proportion of his kilowatt demand; when the consumer costs are assigned to him on the basis of the number of customers; and when the output costs are apportioned to him on the basis of the kilowatt hours used, it is of course found that, while each customer bears only his just share of the respective demand, consumer and output costs, the average cost per kilowatt hour is much higher for those customers who use their service or installation a short time only each day than for those who use their installation for longer periods each day.

These facts possibly can best be illustrated by an example. The following table shows the expenses of an electric plant including fixed charges apportioned among the different classes of consumers and between consumer, demand and output.

	Consumer	Demand	Output	Total	Cost per kilowatt hour sold
					cents
Lighting.....	$37,702.09	$51,308.90	$52,857.55	$141,868.54	6.2
Power.....	1,953.94	14,112.47	21,194.51	37,260.92	4.2
Street lighting.....		8,740.47	7,444.19	16,184.66	5.2
Traction.....		10,895.20	14,917.20	25,813.14	1.9
Total.....	$39,656.03	$85,057.04	$96,413.45	$221,127.26	4.5

The column to the right shows the average cost per kilowatt hour sold for each class of service and also the average cost for the plant as a whole.

A rate schedule under which each customer is made to bear his just proportion, in each case, of the demand, the consumer and the output expenses thus results in higher average rates per kilowatt hour for short than for long hour users. This difference in the rate or cost is just. Since residences or lighting customers are usually short hour users, and power customers are often long hours users, it also follows that the average rate paid per kilowatt hour is higher in the former case.

Those who have analyzed the expenses and the operating conditions generally of public utilities do not find it hard to understand that there are certain items such as fixed charges and stand-by costs that depend on the capacity of the plant, which capacity in turn is determined by the joint demand upon it by the consumers, and that since such is the case these demand costs should also be borne by the consumers in proportion to their demand upon the plant, rather than on any other basis. There surely is a closer relation between those expenses and the demand in question than between those expenses and the kilowatt hours used. Likewise it is quite clear that certain expenses, such as keeping customers' records, collecting the bills and other items of this nature, depend on the consumer; that they are about as great for small as for large customers; that they are much more closely related to the customer than to the kilowatt hours used or any other unit and that for these reasons they ought to be borne in proportion to the number of customers. When it comes to the output costs, however, it is quite obvious that these depend more closely on the kilowatt hours used than on any other unit and that they should therefore be distributed on this basis. Such distributions of the expenses as those just outlined furnish material for the proper kind of cost curves, such curves as are used for scientific and other purposes where accuracy and sound conclusions are required. They especially furnish sound basis for equitable rate schedules.

It is well known that apportionments of the expenses that are required in the classifications outlined can be so made as to be fair to all concerned. There is in the case of all utilities a considerable proportion of items which depend directly upon each branch of the service, and upon each class of customers. Such items can be classi-

fied directly under the branch of the service and under that class for which they were incurred. There are also a considerable number of expense items which are common to two or more classes and two or more branches of service which can be fairly apportioned either on closely related units or on the direct expenses. While such apportionments are often complicated, their trustworthiness when carefully made has repeatedly been established.

The cost basis of rate making thus outlined is also elastic enough to be adjusted to the various conditions that arise in this field. Under it consideration can be given to the long hour user who in addition is also an off-peak user; to the long hour user whose use also extends into the peak hours; to the short hour but off-peak user; to the short hour users whose use also comes during the peak hours and to practically all other conditions that may arise.

Thus in the table shown above we find that the cost per kilowatt hour for street lighting is 5.2 cents. This is for service from dusk until midnight. Let us suppose that it is proposed to burn these lights all night. The question then arises as to what shall be the charge for the additional service. Under a uniform rate the charge would be 5.2 cents per kilowatt hour for all additional current needed. This rate, however, would be too high, because the increased service would not occasion a proportionate increase in the expense. Under the cost basis of rate making the only additional charge that would be made would be one sufficient to cover the increased expense. The following table shows both the direct expense and the expense burden for street lighting separated between demand and output.

Expense	Demand	Output	Total
Direct	$3,960.75	$3,521.66	$7,482.41
Expense burden	4,799.72	3,922.53	8,702.25
Total	$8,760.47	$7,444.19	$16,184.66

It is obvious that the only item that will be affected by an increase in the length of time the lights burn will be the direct portion of the output expense, which in this instance amounts to $3,521.66. If the lights are burned all night the amount of current needed will be doubled and consequently this item will be increased and the total cost of street lighting will be raised to $19,706.32. It will be remem-

bered that the average cost of current when the lamps were burned from dusk until midnight was 5.2 cents per kilowatt hour; if the lamps are burned all night the average cost will be reduced to 3.2 cents per kilowatt hour. This is due to the large proportion of expenses that are fixed in supplying electric service. In other words, it is an industry decidedly subject to the law of decreasing cost. Proper adjustments of this kind are possible only under the cost basis of making rates.

When it comes to the method of charging, however, which, as stated above, is represented by the average cost per kilowatt hour of all the current sold by the plant, the situation is different. The rate thus obtained will be the same regardless of the conditions. Under it the power user would pay the same rate as the lighting user and the long hour user in both cases would be charged as much per unit as the short hour user. If all customers were in the same class, if their demand was the same and also came at the same time, if they used the same amount of current, if there were no competitive or other conditions of this nature to contend against, if, in short, the similarities between them in the situation under which the services were rendered extended to every condition by which the price of the current could be affected, then a uniform meter rate which is the same for all customers would no doubt be practicable. But such similarities are seldom if ever encountered. In actual practice it is found that the demand, the quantity of current used, and other conditions vary, not only as between the different branches of the service, but also as between the different customers or classes of customers in each branch. These differences do not only extend to factors which affect the cost to the plant furnishing the service, but they also cover conditions which measure what the customers can afford to pay for it.

Under a rate schedule, the rates in which represent the average cost for the plant and are therefore the same for all branches of the service and for all classes of customers, the cost for power and for long hour users generally would be so high that the service could not be generally used for industrial and commercial purposes. Manufacturers, for instance, who are producing for the open market cannot afford to use current for power or other purposes unless it can be had at as low cost as power produced by other means. For most plants the average rate is much too high, not only for competitive

business, but for much of the long hour service. Being too high, it also follows that they will not bring the business. Loss of business means loss of revenue. It means more than this. Since the cost per unit of producing current decreases with increases in the business, such restriction in the output not only reduces the revenue, but it increases the costs per unit. It tends to reduce profits and to increase rates and hence results in losses to the plant and higher rates to its customers. No current should be sold at a loss, but the more of it that can be sold at a profit, the better for all concerned. These facts are well understood by the wide-awake manager but seem to be hidden to a large proportion on the outside.

These illustrations may even be carried further. Business which cannot be had on better terms should be taken even if the revenues it produces only slightly exceed the additional cost the plant is put to by taking it on, provided this can be done without unjust discrimination. The amount by which the receipts are greater than such additional cost may be counted as profits, for it aids in meeting the fixed charges of the plant and by its amount reduces the share that otherwise would have to be borne by the rest of the customers. Under the average cost of rate, however, business of this kind could not be had and such rates would therefore tend to restrict the business of the plant at the expense of all concerned.

To make these points a little more clear, let us consider a concrete case. In the table above, which shows the cost of the different classes of service for a particular plant, it will be noted that the total cost assessed to traction is $25,813.14, which is equal to about 1.9 cents per kilowatt hour. One of the reasons that the cost for traction service is so much lower than the other classes is that this current is taken at the switchboard; consequently it is not charged with any of the expenses of distribution. It so happens that 1.9 cents per kilowatt hour is the best price that the utility could get from the traction company. When the costs were apportioned to the different classes of service, it was found, however, that the traction company should have paid $31,790.81, or at the rate of about 2.3 cents per kilowatt hour. But the traction company would rather generate its own current than pay more than 1.9 cents per kilowatt hour. The question then arises whether it is advisable for the utility to take this business at the price named, also whether the other classes of consumers will be injured or benefited if the utility does sell cur-

rent to one consumer at less than cost. In order to answer this question it is necessary to ascertain what additional costs the traction service necessitates, or in other words, what items of expense would be eliminated if the utility stopped supplying current to the traction company, and compare the cost obtained with the revenue that will result from supplying current at the highest rate that the traction company can be induced to pay.

The facts can be set forth as follows:

	Apportioned cost basis	Additional cost basis
Generation expense	$17,443.42	$10,000.00
General expense	2,422.39	.....
Interest, depreciation and taxes	11,925.00	6,982.50
Total	$31,790.81	$16,982.50
Revenue from railway	$25,813.14	$25,813.14
Excess of apportioned cost over revenue	5,977.67	.....
Excess of revenue over additional cost	.....	8,830.64

The load factor of the traction service is about 34 per cent as compared with a load factor of 24 per cent for all other classes combined. This, together with the fact that the traction company takes about 26 per cent of the entire output of the station, seems to indicate that the additional cost for power would not be over $10,000. It will be noted that under the apportioned basis $2,422.39 of the general expenses have been included. Considered from the standpoint of the additional expenses that would be occasioned, none of this item would be assessed to traction.

The generating station has a capacity of 4,200 kilowatts and cost about $103 per kilowatt. Of the total capacity about 900 kilowatts are used for the traction service. It is estimated that if the station had been constructed only large enough to meet the demands of the other classes of service, it would have cost about $115 per kilowatt. The additional investment, then, necessary to furnish current to the traction company amounts to $52,500 or about $58 per kilowatt. Interest, depreciation and taxes on this additional investment, plus the $10,000 of additional operating expense, give a total additional cost of $16,982.50, which leaves an excess of revenue over cost of $8,830.64 to be used in reducing the cost to the other classes

of consumers, as compared with the apparent deficit of $5,977.67, which results when traction is assessed with its proportionate part of all expenses.

The effect on the cost to the other classes of selling current to the traction company at less than the proportionate cost of supplying it, can be readily seen by comparing the cost per kilowatt hour for the other classes of service when current is furnished the traction company, with the cost as it would be if current were not furnished to this company. Under the former condition, the average cost per kilowatt hour is 5.6 cents; under the latter the average cost to the remaining consumers would be 5.85 cents. While this difference appears slight, when presented in this manner, yet it nevertheless proves the point.

The justification of this method of treating some customers when their business cannot be had on a better basis is exhibited a little more vividly when a comparison is made between the cost curve of the business as a whole when traction is included and when traction is excluded, as shown in the following table:

Number hours plant is operated daily	Cost of supplying current when traction is included			Cost of supplying current when traction is excluded		
	Capacity	Output	Total	Capacity	Output	Total
	cents	*cents*	*cents*	*cents*	*cents*	*cents*
1	8.13	1.98	10.11	10.00	2.39	12.39
2	4.06	1.98	6.04	5.00	2.39	7.39
3	2.71	1.98	4.69	3.33	2.39	5.72
5	1.62	1.98	3.60	2.00	2.39	4.39
10	.81	1.98	2.79	1.00	2.39	3.39

It might be well to explain here that the term "capacity" as used in this table is the sum of the "consumer" and "demand" expenses shown in a previous table and is the same as the "fixed" expenses shown in the first illustration; also the "output" expenses are the same as the "variable" expenses referred to above.

It will be noted that the total cost when traction is included starts as 10.11 cents when the plant is operated one hour a day and decreases to 2.79 cents, when the plant is operated ten hours a day. Compared with this the cost when traction is excluded starts at 12.39 cents when the plant is operated one hour a day and decreases to 3.39 cents when the plant is operated ten hours a day. The differ-

ence between the two sets of figures decreases with the increase in the number of hours the plant is operated each day. For one hour of operation this difference is 2.28 cents and for ten hours it is 0.6 cent; consequently rate schedules modeled respectively after these cost curves will show a greater divergence for short hour than for long hour use. From this it follows that the customers who are most benefited by selling current to the traction company at less than the proportionate cost of supplying it, are the customers who use their installations comparatively a short time each day. These are usually residence consumers, the very ones on whom this manner of handling certain consumers is supposed to throw an additional burden. Under a uniform rate such adjustments, of course, would be impossible, and the result would be that regular consumers would have to pay more for current.

A high load factor stands for low costs but a satisfactory load cannot possibly be obtained without rate schedules that for each branch and class of service are as closely adjusted to the cost as is practicable under the circumstances. In the operation and management of a public utility, there is no feature that is of greater importance either to the utility or its customers than a properly adjusted rate schedule.

That such unit costs as those outlined above are of the greatest value in building up proper rate schedules for electrical plants is obvious. They constitute in fact the most important material for these purposes that it is possible to obtain. This is as true when the rate schedules are so constructed as to give separately the customer, the demand and the output charges, as when the customer and the demand charges are covered by meter rates, which decrease in amount with increases in the daily use of the service or installation. In connection with the form alone of the rate schedules, there is much to be said, but the space allowed for this paper does not permit a full analysis of the same.